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Review
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Review

Association Between Cigarette Smoking Prevalence and Income Level: A Systematic Review and Meta-Analysis

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Abstract

Introduction: Previous evidence linked low socioeconomic status with higher smoking prevalence. Our objective was to assess the strength of this association in the world population, updating a previous work.

Methods: Systematic review and meta-analysis of observational studies. Subgroup analyses included continents, WHO regions, country mortality levels, gender, age, risk of bias, and study publication date. Independent reviewers selected studies, assessed potential bias and extracted data. We searched MEDLINE, EMBASE, CENTRAL, SOCINDEX, AFRICAN INDEX MEDICUS, and LILACS, and other sources from 1989 to 2013 reporting direct measurements of income and current cigarette smoking.

Results: We retrieved 13,583 articles and included 93 for meta-analysis. Median smoking prevalence was 17.8% (range 3–70%). Lower income was consistently associated with higher smoking prevalence (odds ratio [OR]: 1.45; 95% confidence interval [CI]: 1.35–1.56). This association was statistically significant in the subgroup analysis by WHO regions for the Americas (OR: 1.54; 95% CI: 1.42–1.68), South East Asia (OR: 1.53; 95% CI: 1.10–2.00), Europe (OR: 1.45; 95% CI: 1.29–1.63), and Western Pacific (OR: 1.32; 95% CI: 1.02–1.72), and in studies conducted during 1990s (OR: 1.42; 95% CI: 1.24–1.62) and 2000s (OR: 1.48; 95%CI: 1.30–1.64). Likewise, it was noted in low-mortality countries (OR: 1.48; 95% CI: 1.37–1.60) and for both genders. Prevalence was highest in the lowest income levels compared to the middle (OR: 1.69; 95% CI: 1.49–1.92), followed by the middle level compared to the highest (OR: 1.31; 95% CI: 1.20–1.43).

Conclusions: Our results show that current cigarette smoking was significantly associated with lower income worldwide and across subgroups, suggesting a dose–response relationship.
Implications: This unique updated systematic review shows a consistent inverse dose–response relationship between cigarette smoking and income level, present among most geographical areas and country characteristics. Public health measures should take into account this potential inequity and consider special efforts directed to disadvantaged populations.

Introduction

Current estimates of tobacco-related deaths project a toll of 400 million adults for the 2010–2050 period.[1,2] Eighty percent of these deaths are expected to occur in low and middle-income countries (LMIC).[3] Since 1980, global prevalence of active smoking declined from 25.9% to nearly 18.6% among adults. However, the number of smokers has increased due to population growth. Almost 800 million men and 200 million women are current cigarette smokers, and smoking prevalence differs markedly among countries with different cultural and economic scenarios. A recent review of data from 187 countries found daily smoking is still more common in high-income countries (HIC) than in LMIC (23.5% vs. 17.9%, respectively).[4] Therefore, tobacco use remains the main preventable health risk factor in HIC.[5]

Although the smoking prevalence declined 25% in men and 42% in women over the last three decades, trends vary among countries with different socioeconomic status (SES).[3,4] Data from 1970 to 2000 show an annual decrease of cigarette consumption of 0.2% in HIC, while figures from LMIC show a 5% increase within the same period.[6] Sales data from 1970 and 2012 shows while consumption diminishes in HIC it increases steadily in LMIC.[7] Prevalence patterns are also remarkably different by gender. The study by Ng et al[4] shows that 30.1% of men in HIC smoke and 32% in LMIC, compared to 17.2% and 3.7%, respectively, in women.[4]

Evidence suggests a change in epidemiology of cigarette consumption. Preexisting data showed an association between SES and smoking which becomes stronger in recent literature, even when both variables were measured using different definitions.[8–12] In a previous systematic review and meta-analysis which included studies up to 2008, we found a strong inverse relationship between smoking prevalence and income across most geographical areas, regardless of gender and age.[13] This pattern was present for studies published from 1990 onwards. Additional analyses revealed that low-income smokers had higher rates of tobacco-related diseases and higher household tobacco expenditures with a negative impact in their finances and health status.[13] The primary objective of the present study was to evaluate the association between cigarette consumption and income level worldwide and to follow the course of this phenomenon updating our previous report.

Methods

An information specialist with expertise in systematic reviews developed a search strategy which was then implemented in the MEDLINE, EMBASE, CENTRAL, SOCINDEX, AFRICAN INDEX MEDICUS, and LILACS databases. This strategy included studies reported from 1989 to April 2013, regardless of publication status, time of recruitment, or language. We also reviewed the reference list from all full text papers retrieved and the International Tobacco or Health Conference Paper Index since 2006. We personally contacted key leaders in tobacco control and consulted relevant agencies, networks, and web-pages.

The simplified MEDLINE search strategy was: (Poverty[Mesh] OR poverty[tiab] OR Income[tiab] OR poor people*[tiab] OR poors[tiab] OR pauper*[tiab] OR Social risk*[tiab] OR Socioeconomic status[tiab] OR Socio economic status[tiab] OR Indigenc*[tiab] OR indigent*[tiab]) AND (Tobacco Smoke Pollution[Mesh] OR Tobacco Use Disorder[Mesh] OR tobacco*[tiab] OR cigar*[tiab] OR Smoking[Mesh:NoExp] OR smoking[tiab] OR smoker*[tiab] OR nicotin*[tiab]), which has been adapted for the other databases. (See Supplementary Appendix 1 for the complete search strategy.)

Selection Criteria

All phases of the study selection and quality assessment were completed using EROS (Early Review Organizing Software, IECS, Buenos Aires), a web-based platform designed to optimize the initial phases of a systematic review.[14,15] Pairs of reviewers with expertise in systematic reviews and tobacco epidemiology independently screened the references by title and abstract to assess their probability of inclusion. Full texts of potentially relevant reports written in English, Spanish or Portuguese were then evaluated for inclusion by the reviewers. Inter-rater agreement for screening was 0.91. Discrepancies were solved by consensus of the whole team. If data were unclear we made attempts to contact the author. Relevant data of included studies were extracted by one reviewer and checked by another using a previously piloted online spreadsheet.

Exposure was defined as any direct measurement of income level, including total household income, personal income, minimum salary, poverty line, and indexes including any of the measurements mentioned. We excluded indirect income proxies such as education level, employment, type of labor, and household assets. The primary outcome measure was prevalence of cigarette smoking (current, daily, or household smoking). No restriction in the definition of smoking were imposed. Only studies reporting adjusted odds ratios (aORs) for both age and gender as their summary measure were considered for the meta-analyses. When a study reported more than two income strata, we chose the aORs for current smoking for the lowest, highest, and the middle stratum, except for those reporting an even number of strata, for which we considered only the lowest and highest.

The risk of bias of included studies was independently assessed by pairs of reviewers, using a tool derived from the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) Statement and two methodological reports (Supplementary Appendix 1).[16–18] Based on this tool, we constructed an algorithm to estimate a summary risk of bias for observational studies rated as low, moderate, high, or very high. This algorithm considered four major domains (methods for selecting study participants, methods for measuring exposure and outcome variables, methods to control confounding, and comparability among groups), and two minor domains (statistical methods [excluding confounding] and conflict of interest). A funnel plot was used to assess potential publication bias (Supplementary Appendix 1). We followed the MOOSE and PRISMA Statements for reporting this study.[19,20]

Statistical Analysis

Stata 11.0 (StataCorp LP, College Station, TX) was used for analyses. A meta-analysis (Mantel-Haenszel model) was performed to obtain summary estimates of aORs with their 95% confidence intervals (CI) from the studies. We chose the DerSimonian–Laird random effect model as we considered the differences observed in design, exposure, comparison groups, participants, and outcome measurement were important sources of heterogeneity.[21] Statistical heterogeneity was evaluated using the I^2 statistic. In order to address the heterogeneity, we performed prespecified subgroup analyses by decade of dataset, WHO region, continents, overall country mortality stratum, risk of bias, gender and age group, and smoking definition (daily smokers, current smokers, or household tobacco use).[22,23] The protocol of the current update followed the published systematic review and is available upon request.[13]

Results

The literature search identified 13 583 references and 1226 studies were retrieved for detailed evaluation. Ultimately, 201 articles met inclusion criteria for descriptive synthesis and 93 reported aORs as their summary measure and were therefore included in the quantitative analyses (Figure 1). Thus, this updated review added 64 papers to the previous version. The main characteristics of the included studies are presented in Supplementary Appendix 2. Ninety percent were cross-sectional studies (n = 84), 5% were cohort studies (n = 5) and 5% were surveillance reports (n = 4). The risk of bias of included studies was considered low in 50%, moderate in 36%, and high or very high in 11%. Visual inspection of the funnel plot did not suggest publication bias (Supplementary Appendix 1). Using the data from the 93 included studies, we were able to analyze 164 separate datasets by gender, age, geographical areas, and smoking definitions, among others.

Included studies had a median of 47.3% males and a median smoking prevalence of 17.8% (range 3–70%). Globally, lower income was associated with significantly higher prevalence of smoking (OR: 1.45; 95% CI: 1.35–1.56) compared to high- income level populations (reference group). This association was observed in most geographical areas considered (Figure 2).

In the subgroup analysis by WHO region, the association was statistically significant for the Americas (PAHO; OR: 1.54; 95% CI: 1.4–1.68), South East (SEARO; OR: 1.53; 95% CI: 1.10–2.00), European (EURO; OR: 1.45; 95% CI: 1.29–1.63), and Western Pacific (WPRO; OR: 1.32; 95% CI: 1.02–1.72), while there was no statistically significant association for the Eastern Mediterranean Region (EMRO; OR: 1.12; 95% CI: 0.82–1.53). In the analysis by continent, we found consistent associations for the Americas, Europe, and Asia. No statistically significant association was observed in Oceania. Only one study was available from Africa (Table 1).

Data retrieved in the 1990s (OR: 1.42; 95% CI: 1.24–1.62) and the 2000s (OR: 1.48; 95% CI: 1.3–1.64) showed a consistent association between exposure and outcome over the last 2 decades. The effect was observed only for subjects older than 15 years of age (OR: 1.50; 95% CI 1.36–1.66). The subset of studies with the lowest risk of bias yielded the strongest association (OR: 1.60; 95% CI: 1.42–1.80). There was a trend toward a stronger association in datasets from women (OR: 1.59; 95% CI: 1.30–1.93) and from low mortality countries (OR: 1.48; 95% CI: 1.37–1.60). (See forest plot in Supplementary Appendix 2).

An examination of smoking prevalence across multiple income strata revealed an inverse dose–response relationship, with the highest prevalence of cigarette use observed in the lowest income levels (OR: 1.69; 95% CI: 1.49–1.92) and intermediate prevalence in the middle income level (OR: 1.31; 95% CI: 1.20–1.43) considering studies assessing three strata of exposure (Table 2).

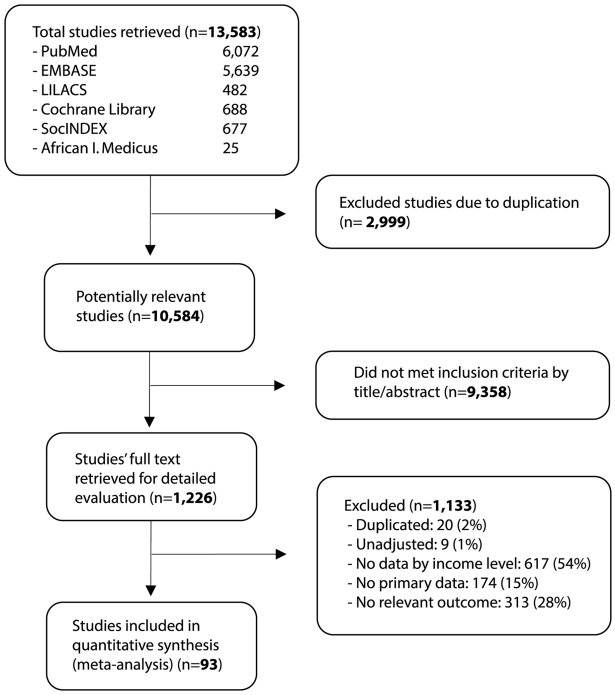

Figure 1. Study flow diagram.

Discussion

Our main finding was a robust association between higher prevalence of cigarette smoking and lower income levels. This finding was consistent for most geographical regions, and especially evident for countries with low mortality according to the WHO classification. The association was also clear among adults and for both genders. A clear gradient of smoking prevalence across income strata was also found. When reviewing studies by decade, only those performed since 1990 showed a strong association. The inverse association among smoking and income level was observed in studies of adults and elderly subjects; however, this was not the case for studies assessing subjects younger than 15 years old. There are important differences between our previous and present reports considering the cumulative volume of research. The present update included 74% more datasets. There was a substantial increase of substudies from South America and Oceania (which increased in 300% and 166%, respectively). (See Supplementary Appendix 3 for details).

Regarding continents, the association was statistically significant for North and South America, Europe, and Asia; however, there was no significant association for Oceania. This continent showed the strongest effect in our previous analysis (OR: 1.65; 95% CI: 1.44–1.90) while our current estimates present no significant association (OR: 1.28; 95% CI: 0.93–1.75).

In this region most of the studies came from Australia and New Zealand, both of which having low smoking prevalence. One plausible explanation is that these countries were the first to implement effective and equity-promoting tobacco control measures. Innovative tobacco control measures as plain packaging have been recently

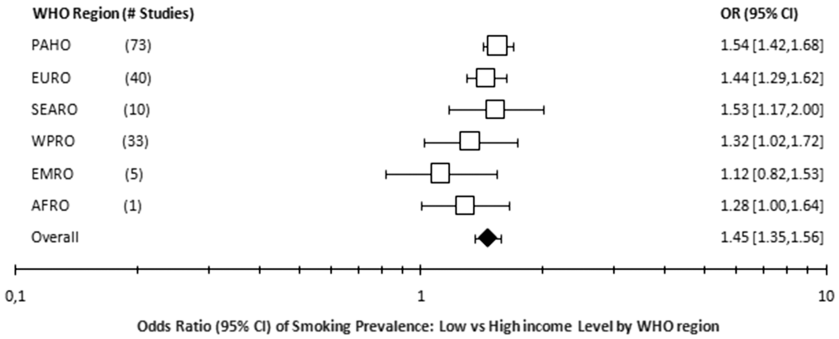

Figure 2. Meta-analysis of adult smoking prevalence: low- versus high-income level by WHO region.

Table 1. Pooled ORs of Smoking Prevalence Comparing Low- Versus High-Income Level by Subgroups

Category	Subcategory	*N* datasets	OR (95% CI)	I^2 (%)
All datasets		164	1.45 (1.35–1.56)	98.8
By decade of dataset				
	<1989	15	1.03 (0.99–1.08)	79.1
	1990–1999	49	1.42 (1.24–1.62)	98
	2000–2009	89	1.48 (1.33–1.64)	98.7
By continent				
	North America	61	1.53 (1.39–1.67)	93.3
	Oceania	24	1.28 (0.93–1.75)	99.6
	Europe	38	1.45 (1.29–1.63)	95.2
	Asia	26	1.39 (1.20–1.62)	91.6
	South America	12	1.63 (1.37–1.94)	40.2
	Africa	1	1.28 (1.00–1.64)	
By WHO region				
	PAHO	73	1.54 (1.42–1.68)	98.7
	SEARO	10	1.53 (1.17–2.00)	90
	EURO	40	1.44 (1.29–1.62)	92.1
	WPRO	33	1.32 (1.02–1.72)	99.3
	EMRO	5	1.12 (0.82–1.53)	90.5
	AFRO	1	1.28 (1.00–1.64)	0
By country mortality stratum				
	Low (stratum A + B)	143	1.48 (1.37–1.60)	99
	High (stratum C + D + E)	21	1.28 (1.09–1.50)	84.4
By outcome definition				
	Daily smokers	42	1.45 (1.25–1.67)	95.9
	Current smokers	113	1.44 (1.32–1.57)	99.1
	Household smoking	2	1.54 (0.83–2.88)	58.3
	Not reported	7	1.60 (1.05–2.43)	96.6
By age group				
	<15	12	0.99 (0.73–1.35)	96.3
	15–44	89	1.50 (1.36–1.66)	98.8
	45–64	5	1.73 (1.58–1.89)	36.6
	65+	4	1.90 (1.22–2.96)	90.9
By gender				
	Female	55	1.59 (1.30–1.93)	99.4
	Male	44	1.38 (1.27–1.49)	92.5
Risk of bias				
	Low	71	1.60 (1.42–1.80)	98.8
	Moderate	49	1.28 (1.14–1.43)	96.4
	High	42	1.32 (1.25–1.40)	89.9

[a]WHO region: African Region (AFRO), Region of the Americas (PAHO), Eastern Mediterranean Region (EMRO), European Region (EURO), South-East Asia Region (SEARO), and Western Pacific Region (WPRO).[b]Stratum: A = very low child mortality and very low adult mortality; B = low child mortality and low adult mortality; C = low child mortality and high adult mortality; D = high child mortality and high adult mortality; E = high child mortality and very high adult mortality.

Table 2. Pooled ORs of Smoking Comparing High-Income Level Versus Low- and Medium-Income Level, Considering Only Studies With Three Categories Analyzed

Category	*N* datasets	OR (95%CI)	I^2 (%)
All studies	67		
Low vs. high income		1.69 (1.49–1.92)	98.5
Medium vs. high income		1.31 (1.20–1.43)	97.5
By gender			
Female	24		
Low vs. high income		1.82 (1.39–2.38)	98.9
Medium vs. high income		1.37 (1.08–1.73)	98.1
Male	20		
Low vs. high income		1.56 (1.42–1.71)	75.4
Medium vs. high income		1.22 (1.14–1.31)	61.2
By age group			
>15	38		
Low vs. high income		1.73 (1.45–2.05)	99.3
Medium vs. high income		1.32 (1.17–1.49)	98.5
<15	3		
Low vs. high income		1.09 (0.45–2.64)	96.7
Medium vs. high income		1.00 (0.60–1.68)	94.3

introduced in the region and their effectiveness is an interesting subject for future research.[24–26] Other areas where the effect was nonstatistically significant were the EMRO region—where data were only limited to Pakistan and Saudi Arabia—as well as the AFRO region, with insufficient data to draw conclusive results. A recent survey of 30 sub-Saharan African countries found that smoking and use of smokeless tobacco were associated with lower SES measured by living standards index, which is also consistent with the observed trend.[27] In comparison with our first meta-analysis, the rank of values for association by continent changed. The new results position the Americas as the areas with the strongest association, probably due to the increased amount of datasets included. However, a careful look at confidence intervals reveals substantial overlap which points to a global phenomenon. (See Supplementary Appendix 3 for details).

Our summarized results show differences in smoking by income group are more marked in low mortality countries. Patterns of relative inequality vary widely within countries.[28] Some societies present big differences in smoking distribution between higher and lower income groups, while in others these are less evident. However, a lower number of datasets from high mortality countries limits our ability to assess this issue.

The inverse association was present across adults but not in subjects younger than 15 years old. Several studies suggest adolescents from families with lower SES, including those living in single-parent

homes, are at increased risk of smoking initiation.[28,29] However, as adolescents' available money may not be related to household income (most studies used family income), the association with smoking prevalence could be obscured. Lack of precision due to scarcity of data precludes us from arriving at definitive conclusions.

While the association was found for both genders, we observed a trend for a stronger association in women. Lopez et al[12] presented in the 1990s the four-stage model to describe a differential behavior of tobacco prevalence and mortality by gender and country development stage.[30] According to this model, women begin smoking later than men and reproduce their behavior over time without reaching a comparable prevalence.[12] Mortality by genders follows this pattern with a long delay. Recent data show that this framework still provides a reasonably useful description for developed countries while its relevance to developing countries is limited.[30] Furthermore, results by Ng et al[4] show a greater proportional reduction of the global prevalence in women than men. Among other factors, tobacco companies have been aiming their marketing strategies at low income females for several decades, including price discounts at the point of sale targeting cheaper brands and promoting luxury images.[31]

The results of this updated meta-analysis restated the association and weighted its magnitude. Compared with our previous study, the overall and subgroup effects magnitudes were similar, while the OR ranking for continents changed. We found no systematic reviews summarizing the association of other demographic or social determinants of smoking, but one of the largest primary studies in our review that surveyed 48 LMIC showed consistent results with our pooled estimates.[28]

Low income as a risk factor for smoking should be addressed alongside others. A recent review of data from 13 LMICs included in the Global Adult Tobacco Survey (GATS) found associations with male gender (ORs between 162.2 and 2.08), rural residence compared to urban (ORs between 1.24 and 0.78), and age group between 45 and 54 years compared to 15–24 years (ORs between 12.8 and 1.31). The strength and direction of the associations varied widely between countries surveyed.[32] The World Health Survey also found that unmarried males had a higher risk of smoking in middle (OR: 1.79) and low income countries (OR: 1.59).[28]

The main strength of our study is the use of established methods for a comprehensive literature search, criteria for quality assessment of studies, and a preplanned analysis strategy to deal with anticipated levels of heterogeneity that included subgroup analyses and the use of the random-effects model.[21]

There are several potential limitations to our review. Included studies presented a wide variety of epidemiological designs and risks of bias. The observational nature of studies, different geographical settings, designs, and definitions of exposure and outcome resulted in markedly high I^2 values for most of meta-analyses. Nevertheless, those with the lowest risk of bias yielded the strongest values of association, and there was no evidence of publication bias. Measuring SES can be challenging, as income level could act as a limited indicator due to under-reporting and fluctuation over time. Different indicators are used to overcome its limitations (i.e., consumption figures, educational level, assets' indexes, and other measurements of living standards). However, they are more difficult to summarize in a unique exposure variable, posing a challenge when performing a systematic review. The additional indicators are also more likely to associate with smoking in a similar fashion.[33–35] Educational attainment may also play a role.[36] Several studies found lower educational level was associated with tobacco consumption in LMIC but its influence was beyond the scope of our work.[28,32] In our analysis, we used the definition of strata of income provided by the authors, which may introduce some variability in criteria and results, although not likely to affect the overall results and the trend by income strata.

Regarding the outcome variable, studies included a spectrum of definitions of smoking which may affect prevalence rate; however, results were robust across subgroups of every smoking definition.[37] We only included studies of cigarette smoking as it is the most common form of tobacco use. Therefore, results cannot be extrapolated to other forms of consumption, such as smokeless tobacco, which are prevalent in some regions.[38] Most studies came from developed, low-mortality areas but the subgroup analysis of datasets by mortality level showed similar results.

As part of a marketing strategy, smoking has been glamorized by the tobacco industry by associating its use with wealth and success. As a result, disadvantaged groups may be more susceptible to this strategy. Higher tobacco consumption in low-income groups may be explained by several other related factors such as their present-oriented nature (that makes them prioritize the immediate reward of nicotine despite future health risks), frequent normalization of smoking with earlier initiation, less concern about harm, poorer access to cessation resources and more difficulty with successfully quitting.[39–41] Our results show that differences in tobacco consumption between income groups are more marked in HIC despite the fact that they have achieved greater declines in smoking prevalence. This may be due to these countries' ability to implement tobacco control policies and achieve greater awareness of associated health risks among high-income populations.

The impact of tobacco control policies such as those proposed by the WHO Framework Convention on Tobacco Control varies by SES and its differential effect should be monitored.[39] A recent review found that increases in tobacco taxation have the greatest potential to reduce socioeconomic inequalities in smoking.[40] When tobacco prices increases, poorer people incur an increasingly higher opportunity cost of tobacco, reducing their consumption more than richer people.[39] More research needs to be done to investigate the association of income level and smoking behavior in populations of LMIC and younger groups and their responsiveness to price variations to explore further the extent and the temporal evolution of the association. Such future studies should use direct measures of income alongside multiple indicators of income, and standardized definitions of smoking. More research is also needed in countries from Middle East and Africa considering the evidence gaps, high poverty rates, intermediate to high male smoking tobacco-related illness prevalence, and frequent use of other forms of tobacco.[27]

In conclusion, the results of this updated review show a consistent inverse dose–response relationship between cigarette consumption and income level. Furthermore, it demonstrates the strength and consistency of this association among adults for most geographical areas and country characteristics. Risk of smoking is clearly higher among economically disadvantaged groups.

Supplementary Material

Supplementary Appendix 1–3 can be found online at http://www.ntr.oxfordjournals.org

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Declaration of Interests

All authors declare no support from any organization for the submitted work, no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years and no other relationships or activities that could appear to have influenced the submitted work.

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